

SUPRACLAVICULAR ARTERY PERFORATOR FLAP IN MANAGEMENT OF POST-BURN NECK RECONSTRUCTION: CLINICAL EXPERIENCE

LAMBEAU ARTÉRIEL PERFORANT SUPRA CLAVICULAIRE DANS LE TRAITEMENT DES RÉTRACTIONS POST BRÛLURES: EXPÉRIENCE CLINIQUE

Ismail H.,¹✉ Elshobaky A.²

¹ Plastic Surgery Department, Mansoura University, Mansoura, Egypt

² General Surgery Department, Faculty of Medicine, Mansoura University, Mansoura, Egypt

SUMMARY. Anterior cervical contractures of the neck represent a great challenge for plastic and reconstructive surgeons. Necks can be reconstructed with a wide range of surgical techniques, including chimeric flaps, supercharged flap, pre-expanded flaps, "superthin" flaps and perforator flaps. The supraclavicular flap is easy to harvest without the need for free tissue transfer. It provides a relatively large flap for neck resurfacing with tissue very similar to that of the neck. Between January 2013 and March 2015, 20 patients suffering from post-burn neck contracture underwent reconstruction with 20 unilateral supraclavicular artery perforator flaps. Nineteen patients had post-burn neck contractures (9 cases type Ic, 10 cases type IIc) while only one had post-burn granulation tissue in the neck. We harvested fifteen flaps from the right side and five from the left. Size of the reconstructed defect ranged from 23x10 to 14x6, and flap size varied from 25/11 to 16/7cm. Period of follow up ranged from 27-2months (average 12.3). Nineteen flaps survived well (95% survival rate): only one was lost due to iatrogenic extensive dissection over the pedicle. Five cases showed distal superficial epidermolysis, and 2 cases showed 2 cm complete distal necrosis. All patients were managed conservatively. Our results coincide with other literature results confirming the efficacy and rich vascularity of this flap. In all cases with distal partial necrosis, flaps were 23 cm or more. We recommend that supraclavicular flaps of more than 22 cm in length are not harvested immediately and that flaps are expanded before harvesting. Expanding the supraclavicular flap increases its surface area and decreases donor site morbidity.

Keywords: supraclavicular flap, post-burn neck contracture, pedicled supraclavicular perforator flap, fasciocutaneous flap

RÉSUMÉ. Les rétractions cervicales antérieures après brûlure représentent un grand défi pour la chirurgie plastique et reconstructrice. Le cou peut être reconstruit grâce à un large choix de techniques chirurgicales incluant les lambeaux chimériques, suralimentés (supercharged flaps), pré expansés, superfins, et enfin les lambeaux perforants. Le lambeau supra claviculaire est facile à lever sans les contraintes du lambeau libre. C'est un lambeau relativement grand, utilisable pour la reconstruction de la région cervicale, procurant un tissu très similaire à celui du cou. Entre janvier 2013 et mars 2015, 20 patients présentant des rétractions du cou après brûlure ont été traités par 20 lambeaux perforants supra claviculaire de façon unilatérale; 19 patients présentait des rétractions (9 cas type I c, 10 cas type II c) tandis qu'un seul présentait une plaie granuleuse du cou. Nous avons levé 15 lambeaux du côté droit et 5 du côté gauche. La taille de la perte de substance à reconstruire allait de 23 x 10 jusqu'à 14 x 6, et la taille du lambeau de 25 /11 à 16 /7 cm; la période de suivi a été de 27 à 2 mois (moyenne 12,3). 19 lambeaux ont survécu de façon correcte (95% de taux de survie): un seul lambeau a été perdu à cause d'une dissection extensive iatrogénique au-delà du pédicule. Cinq cas ont présenté une épidermolyse superficielle distale et 2 cas une réelle nécrose distale sur 2 cms. Tous les patients ont été complètement pris en charge. Nos résultats sont superposables aux autres résultats de la littérature confirmant ainsi l'efficacité et la riche vascularisation de ce lambeau. Dans tous les cas où nous avons observé une nécrose distale partielle, les lambeaux mesuraient 23 cm et plus. Nous pensons que ces lambeaux supra claviculaires de plus de 22 cm en longueur ne doivent pas être levés immédiatement, mais expansés préalablement. L'expansion du lambeau supra claviculaire augmente sa surface et diminue la morbidité du site donneur.

Mots-clés: lambeau supra claviculaire, rétraction du cou après brûlure, lambeau perforant supra claviculaire, lambeau fascio cutané

Introduction

The anterior neck is a very difficult area to reconstruct because the neck connects the head to the body with multidirectional and complex motility. Therefore, post-burn neck contractures and post-oncological defects of the neck represent

a great challenge for plastic and reconstructive surgeons.

Anterior cervical contractures are characterized by restrictions in range of neck motion, especially extension. Physical and aesthetic abnormalities resulting from this type of distortion can cause extreme depression.¹ Moreover, patients with soft tissue neoplasms of the neck require reliable local, regional

✉ Corresponding author: Hossam El-Din Ali Ismail, MD, Plastic Surgery Department, Mansoura University, 35516 El-Gomhoria St., Mansoura, Egypt. Tel.: +20-502349020; email: dr.hossam.ismail@gmail.com

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or free flaps to reconstruct both form and function.²

The necks of those patients can be reconstructed with a wide range of surgical techniques, including chimeric flaps,³ supercharged flaps,⁴ pre-expanded flaps,⁵ "superthin" flaps⁶ and perforator flaps.⁷

Among the different options available, the supraclavicular flap is excellent as it is similar in colour, thickness and texture to the recipient area, and the operative technique is simple.

In the past decade, this flap has been widely used and discussed.⁸ Anatomical studies supporting it have been performed.⁹ The pre-expanded flap¹⁰ and bilobed flap versions¹¹ have been developed. Moreover, a new subtype based on the anterior supraclavicular artery perforator flap has been harvested with satisfactory results.¹²

In 2009, Vinh et al. reported a high survival rate in a large series study of supraclavicular flaps used specifically to treat neck contractures.¹³ Therefore, the pedicled or island supraclavicular fasciocutaneous flap provides thin, pliable, well-vascularized tissue that is an excellent match in terms of skin colour and texture, and is ideal for replacing external skin losses in neck reconstruction.¹⁴

In the current study we aim to present our clinical experience of using the supraclavicular flap for neck reconstruction, and determine the maximum dimension that allows function and aesthetic appearance of the neck to be restored.

Patients and methods

This study was carried out in the Plastic Surgery Department of Mansoura University between January 2013 and March 2015. It involved 20 patients (13 females and 7 males) who were suffering from post-burn neck contracture, and who were subjected to reconstruction with 20 unilateral supraclavicular artery flaps. Mean age was 25.5 years (range 48-16

years). Nineteen patients had post-burn neck contractures (9 cases of type Ic, 10 cases of type IIc) while only 1 had post-burn granulation tissue in the neck. We harvested fifteen flaps from the right side and five from the left. The size of the reconstructed defect ranged from 23x10 to 14x6, and the size of the flap varied from 25/11 to 16/7cm. Follow-up period ranged from 27-2 months (average 12.3) (Table I).

The following absolute and relative exclusion criteria were considered in the study. Absolute criteria: patient not fit for surgery, burnt donor site, previous block dissection of the neck or previous neck irradiation. Relative criteria: smokers were supposed to stop smoking at least one month before the procedure, and diabetic patients were supposed to have good diabetic control before the procedure.

Operative procedures

The perforator was detected pre-operatively with the aid of a hand-held Doppler signal in the triangular fossa, bordered by the clavicle inferiorly and the sternocleidomastoid anteriorly, asking the patient to push his head to the opposite side, and finally by the external jugular posteriorly (Figs. 1, 2a, 3a).

Flap size was determined according to the size of the recipient site defect. Flap shape was marked out according to the type of flap design i.e., if the flap was designed to be a pedicled flap, the flap was then marked out as a rectangle. The boundaries were the border of the trapezius muscle posteriorly, lower border of the clavicle inferiorly, the mid-deltoid muscle position laterally and skin proximal to the perforator as the medial border (Fig. 1).

If the flap was designed to be an island flap, a fusiform shape was marked out over the shoulder depending on an adipofascial pedicle containing the artery or not. Those without adipofascial pedicle had a fusiform marking extending medially to the perforator site.

Table I - Patients' demographic data

No.	Age/yr	Sex	Cont. type	Side	Defect size	Flap size (cm)	Flap type	Donor site	Follow up (months)
1	16	M	Ic	Rt	21×9	23×10	pedicled	PTSG	27
2	20	M	IIc	Lt	19×8	21×9	pedicled	PTSG	25
3	45	F	Ic	Lt	14×6	16×7	island with adipofascial pedicle	lry	23
4	40	M	Ic	Rt	18×7	20×8	pedicled	lry	21
5	16	F	Ic	Rt	16×9	18×10	island	PTSG	20
6	23	F	IIc	Lt	20×7	22×9	island	PTSG	19
7	25	M	IIc	Rt	16×8	18×9	pedicled	PTSG	17
8	33	M	Ic	Rt	23×10	25×11	pedicled	PTSG	16
9	18	F	IIc	Rt	18×8	21×9	pedicled	PTSG	14
10	29	M	Ic	Lt	21×10	23×11	pedicled	PTSG	12
11	22	F	Ic	Rt	18×8	20×9	pedicled	lry	10
12	20	F	IIc	Rt	22×7	24×8	pedicled	lry	9
13	48	F	IIc	Rt	20×6	22×7	island	lry	8
14	29	F	IIc	Lt	18×8	20×9	pedicled	PTSG	6
15	21	F	PBGT	Rt	23×9	25×11	island	PTSG	5
16	26	F	Ic	Rt	21×10	23×11	island	PTSG	4
17	19	M	IIc	Rt	21×10	23×11	pedicled	lry	3
18	23	F	IIc	Rt	19×10	21×11	pedicled	PTSG	3
19	20	F	IIc	Rt	22×10	24×11	island	lry	2
20	17	F	Ic	Rt	21×8	23×10	island	PTSG	2
Mean	25.5								12.3

*PBGT: Post burn granulation tissue

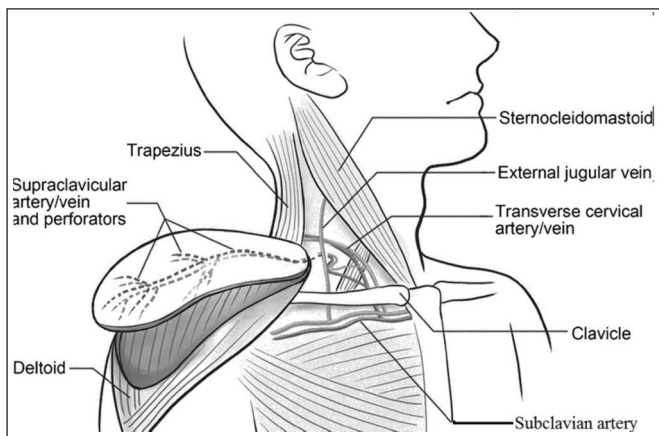


Fig. 1 - Schematic diagram of the anatomical study of the supraclavicular artery, which is a branch of the transverse cervical artery, the main vascular supply of the supraclavicular fasciocutaneous flap. The pedicle was found mainly in the triangle between the dorsal edge of the sternocleidomastoid muscle, the external jugular vein, and the middle third of the clavicle.¹⁵

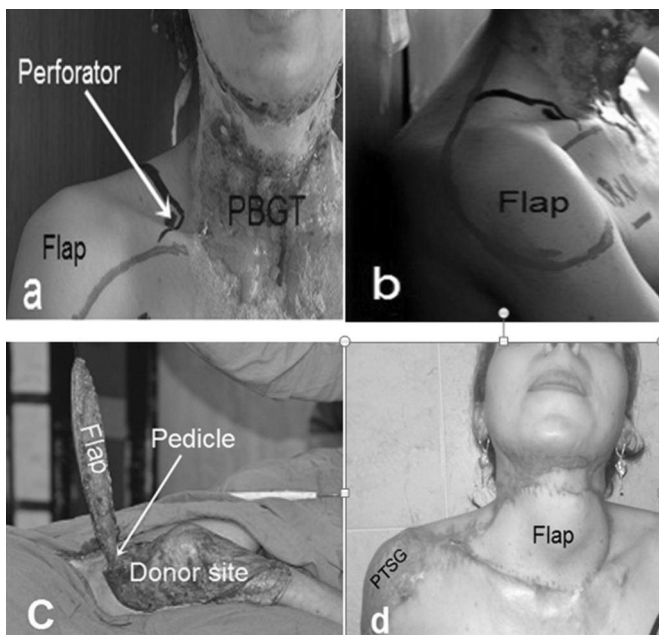


Fig. 2 - 20-year-old female patient with post-burn granulation tissue of the neck. (a) Flap Design. Intact perforator beside the burnt neck; (b) Pre-operative marking of the flap harvested from the right shoulder; (c) After complete harvesting of the flap; (d) Four weeks postoperative, showing healed flap and graft. The patient was able to extend her neck completely.

Surgical technique

The patient lay in a supine position with silicone pillows under the donor shoulder for proper exposure. The entire upper limb was abducted to 90 degrees on a small table beside the patient. All the patients had general anaesthesia. Anaesthesiologists gave special consideration to intubation. In the event of difficult intubation due to severe neck contracture, anaesthesiologists used laryngeal masks, fiberoptic laryngoscopy and tracheostomies. The neck and the entire arm and hand were sterilized with Bovidine iodine solution.

Skin incision was started on the distal part of the flap, reaching to the subfascial plain. Dissection of the flap proceeded in the same plain from distal to proximal toward the pedicle using electrocautery. Also, sutures were placed to keep

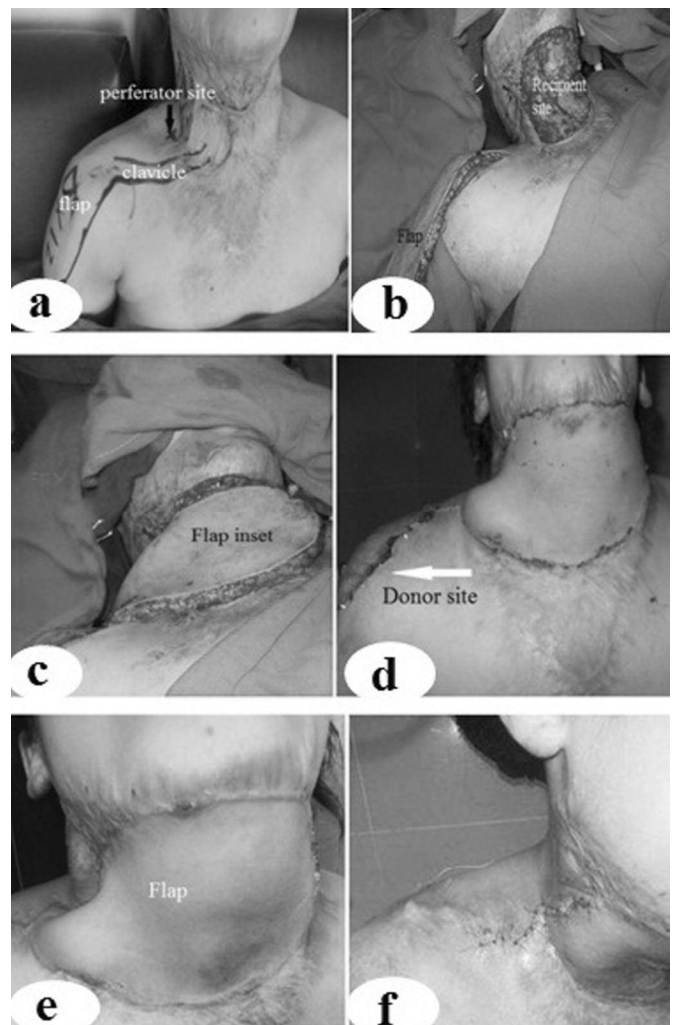


Fig. 3 - 18-year-old female patient presented with grade IIc post burn neck contracture. (a) Preoperative marking of supraclavicular flap from the right shoulder; (b) After complete flap harvesting in a subfascial plane, excision of the cicatrizing tissue guided by the harvested flap; (c) Flap inset in the defect; (d) Seven days postoperative, complete survival of the flap and graft over the shoulder; (e) Three months postoperative, with mild hypertrophic edges. Note the dog-ear on the left side before excision; (f) Three days after dog-ear excision.

the fascia and the dermis together (*Fig. 2c*).

Once we were in the vicinity of the pedicle, we switched to blunt dissection to avoid injuring the perforator. After the pedicle was identified, the proximal skin island was cut, so that the island flap had ample room to rotate. The length, vessel diameter and location of the pedicle entering the flap island were the limiting factors with regard to the volume of tissue that could be transferred. In the pedicle flap the skin was cut back, leaving a small dog-ear shaped portion of tissue that could be divided later on in a separate, simple, secondary procedure. The arterial signal inside the flap was confirmed intraoperatively. Trans-illumination in some cases was conducted to trace the course of the artery in the flap. The distal end was trimmed in some cases, especially in large flaps, to ensure distal vascularity. In post-burn contracture cases, the entire cicatrix was excised, maximum extension was obtained, and haemostasis was then done very carefully. At the flap inset stage, the flap was rotated medially (*Fig. 3c*). After the flap was inset, the wound was closed in two layers; the subcutaneous one was se-

cured with absorbable suture (polyglactin 2/0) and the skin secured with a non-absorbable one (polypropylene 4/0). The donor site was closed after flap inset. Wide undermining, both anteriorly and posteriorly, was usually required. Usually the part over the pedicle was easily closed primarily. A suction drain was used in donor sites closed primarily.

Any flap wider than 8 cm may be difficult to close, and skin grafting over the shoulder must be performed without hesitation. Steri-strips were used over the closed wound, and the entire limb was loosely wrapped with crepe bandage.

Postoperative

All the patients lay with their heads semi-flexed to prevent severe extension or flexion, and prevent the pedicle from being severely stretched or kinked in the recovery room. The patients continued to receive IV 3rd generation cephalosporin for 7-10 days. The flap was monitored after the procedure: every 4 hours on the first day, then every 12 hours over the following days to assess temperature, colour, capillary refilling, pin-prick test, firmness, possible hematomas, drains, the patient's general condition, position and airway. The drain was removed after 48 hours. The patients were discharged 10 to 14 days postoperatively and followed-up at regular intervals.

The patients were followed regarding full range of movement, delayed complications, aesthetic appearance and patient satisfaction. Mean follow-up period was 9.8 months (range 20-2 months).

Secondary procedures

Secondary procedures included those simple procedures done during follow up to obtain maximum results.

Z-plasty was performed in two cases that developed a small contracture band at the edge of the flap. The procedure was simple and the cases were discharged the following day.

Dog-ears were excised in two cases with pedicled flaps. This was done three months after the procedure when flap vascularity had been established. This too was a very simple procedure, and the patients were discharged the following day. The interesting thing was that the rest of the pedicled cases did not need any revision of their flap dog-ears as they were remodelled during the healing process.

Results

This study was conducted on 20 patients, 13 females and 7 males, with an average age of 25.5 years (16-48 years). Nineteen had post-burn neck contractures (9 cases of grade Ic, 10 cases of grade IIc) while only one case had post-burn granulation tissue due to a deep burn wound in the neck. All cases were reconstructed with a supraclavicular artery flap. We harvested fifteen flaps from the right side and five from the left. We used a partial thickness skin graft for donor site closure in 14 cases and closed primarily in 6 cases.

We harvested flaps of various lengths according to the expected defects after excision of cicatrizing tissue. Flap length ranged from a minimum of 16 cm to a maximum of 25 cm. Mean length was 21.7 cm, with a standard deviation of 2.52 (*Table II*).

The width of the flaps harvested ranged from a minimum of 7 cm to a maximum of 11 cm. Mean width was 9.7 cm, with a standard deviation of 1.17 (*Table II*).

In our study, the harvested flaps had a relatively large sur-

Table II - Statistical analysis of flap dimensions

Flap	length	width	surface area
Minimum	16 cm	7 cm	144
Maximum	25 cm	11 cm	275
Mean	21.7	9.7 cm	211.6
Standard deviation	2.52	1.17 cm	42.2

face area, ranging from a minimum of 144 to a maximum of 275 with a mean of 211.6 cm² and a standard deviation of 42.2 (*Table II*).

Six cases (30%) were closed primarily with no need for skin graft, and 14 cases (70%) were closed with partial thickness skin.

The following complications occurred: hematoma in 2 cases (10%), partial distal necrosis in 7 (5 cases of superficial epidermolysis [25%] + 2 cases of full thickness necrosis [10%]), total flap necrosis in 1 case (5%) and disruption of the wound in 2 cases. As regards donor site complications, hypertrophic scars around the edges of the graft occurred in 6 cases.

Discussion

Patients with post-burn neck scar contractures usually exhibit severe restriction of neck movement and related deformities such as stiffness in the shoulders, compensatory kyphosis posture, lower lip cicatricial ectropion, and incomplete oral occlusion with drooling of saliva. Therefore, scar contractures and deformity in the neck region after burns represent a challenge with a unique set of problems for the reconstructive surgeon, compared with the rest of the body.¹⁶

Local flaps for neck reconstruction are harvested from the chest, back or cervico-humeral region. The chest can offer reconstructive surgeons pectoralis muscle flaps or deltopectoral flaps. The back can provide trapezius fasciocutaneous flaps.¹⁷

The cervico-humeral area offers random pattern flaps, described 150 years ago by Mütter and then later by Zovickian.¹⁸ This area also provides musculocutaneous flaps based on trapezius muscle. They are either based on the occipital artery or deep and superficial branches of the transverse cervical artery, as described by Aranmolate and Attah.¹⁹

Various studies have been conducted over the years: superthin flaps for neck scar contracture reconstruction were advised by Hyakusoku and Gao. These studies discovered that the shoulder skin is very reliable for neck reconstruction and resurfacing.²⁰

Lee and Hwang assessed the thickness of the skin in the cervico-humeral area. They concluded that the skin of the supraclavicular fossa and adjacent skin over the upper half of the deltoid has even thinner skin (958.6 µm for men and 558.8 µm for women) than that of the neck.²¹

After further studies on vascularity in that area, especially branches of the thyro-cervical trunk, a new fasciocutaneous flap from the cervico-humeral area appeared. It was named the supraclavicular flap and was first described by Lamberty and Cormack.²²

In 1997, Pallua et al.²³ reviewed the flap with good, reliable results. These results encouraged further studies by other researchers, such as Vinh et. al.²⁴ DiBenedetto et al.²⁵ as well as by himself.^{26,27} Their results were very reliable as regards survival rates and minimal complications.

Since then, the supraclavicular artery flap has been con-

sidered an important development in neck reconstructive surgery. The flap was harvested either pedicled or as an island, with rotation up to 180 degrees, as described by Pallua and Noah's modification.²⁸

In 2007, Laredo et al.²⁹ modified it further by dividing flaps into two lobes: one for release of small contractures, the other for closing the donor site primarily.

The supraclavicular flap is considered the 'workhorse' of local neck reconstruction flaps due to a number of advantages, namely quick harvesting technique, close match as regards texture and colour of neck skin, a very wide arc of rotation and relatively long pedicle if designed as an island flap, allowing nearly all of the flap surface area to be settled in relatively large defects. Also, its pivot point is just adjacent to the neck, allowing more utilization of the whole flap surface area unlike other local flaps like deltopectoral or trapezius flaps. It has more simple surveillance after the procedure regarding free tissue transfer. Its donor site over the shoulder can be well hidden. Another of its great advantages is the single stage flap closure, unlike the deltopectoral flap, which has a 2nd stage for division after 3 weeks. That one stage procedure, plus the above-mentioned advantages, has made it a worthy reconstructive procedure in recent years.

In our study, flap length ranged from a minimum of 16 cm to a maximum of 25 cm, with a mean of 21.7 cm. This result is very similar to that of Loghmani et al. Their clinical series was on 34 patients with post-burn neck contracture. Maximum length was 24 cm and minimum was 16 cm, with a mean of 21.2 cm.³¹

In 2012, Balakrishnan and Sivarajan conducted 16 cases of supraclavicular flap for release of neck contractures. Mean length of their flaps as 22.7 cm. The difference comes from harvesting flaps of up to 33 and even 35 cm without complications.³²

We agree more with Vinh et al. who, in 2009, said that immediate harvesting of flaps longer than 22 cm makes the distal vascularity of the flap questionable. He reported that if longer flaps need to be harvested, he would recommend the supercharged flap or flap pre-expansion.¹³

We think that the 7 cases of distal flap necrosis in our study were attributed to arterial insufficiency. In all cases flaps were 23 cm or more.

This is not possible with any other local flap. For example, in 2014 Chan and Chan³³ conducted a study on the deltopectoral flap. Mean flap length was 16.3 cm: moreover its pivot point was low in the chest opposite the 2nd and 3rd intercostal perforator. Thus, the relatively distant perforator site makes a large part of the flap consumed in the arc of rotation. Consequently, this flap cannot be used for neck resurfacing. All this makes the deltopectoral flap, which has been used for years for neck reconstruction, incomparable with the supraclavicular flap as regards length or width.

In the current study, minimum width was 7 cm and maximum was 11 cm, with a mean width of 9.7. This coincides with a mean width of 10.1 cm in the Loghmani et al.³¹ study. Vinh et al. reported a similar result, with a maximum width of 11 cm.¹³

On the other hand, Balakrishnan and Sivarajan reported a much wider range of flap width, up to 27 cm with a mean width of 21.8 cm. They think that the reason for this is recruitment of the external jugular vein and middle supraclavicular nerve in the flap.³²

Flap width is extremely important to regaining both function and aesthetic appearance through neck resurfacing with a relatively wide flap. In other words, besides a free flap, e.g. a free anterolateral thigh flap, only a supraclavicular flap of such width can be used as a local resurfacing flap. This is due to its reasonable width that is used to completely fill the neck defect, i.e. no part is consumed in the rotation arc as its pivot point is just adjacent to the neck.

It is thought that the external jugular vein allows more adequate drainage, and the middle supraclavicular nerve recruitment prevents immediate sympathectomy that causes adrenergic hypersensitivity. Although all our flaps were sensate and described by our patient as a referred sensation to the donor shoulder, we do not think that nerve included in the flap is a reason for harvesting these larger flaps.

Survival rate in this study was 95% (19 cases). Only one flap was totally lost. Vinh et al. reported a similar rate of 98%, with only 2 out of their 103 cases having flap necrosis.¹³ Balakrishnan and Sivarajan reported a 100% survival rate,³² whereas Loghmani et al. reported a 96.9% survival rate.³¹

Our case with total flap necrosis was a 45-year-old female. The cause was arterial insufficiency with absolute ischemia all over the flap detected in postoperative follow up. We think that this insufficiency was iatrogenic due to extensive dissection around the perforator that perhaps caused injury or severe spasm of the artery.

That is what Sadu et al. explained in their study, confirming that when the flap can be settled well in the defect without tension, it is advisable to leave a cuff of soft tissue around the pedicle.³⁴

So, as a golden rule, stop any further dissection once you reach the defect comfortably with the harvested flap.

We reported that 7 cases (35%) showed partial distal necrosis either in the form of superficial epidermolysis in 5 cases (25%) or full thickness necrosis of the distal two centimetres as a maximum in 2 cases (10%). All our cases were managed conservatively after the procedure. Two cases later exhibited a contracture band at the wound edge healed with secondary intention. They were simply managed with Z-plasty.

Vinh et al.¹³ reported 3.9% distal superficial necrosis, whereas Loghmani et al.³¹ and Balakrishnan and Sivarajan³² reported 6.3% (1 case) and 9.3% (3 cases) respectively. In all our cases with distal partial necrosis, flaps were 23 cm or more.

Conclusion

We recommend that supraclavicular flaps longer than 22 cm are not harvested immediately. We recommend flap expansion before harvesting.

Expansion of the supraclavicular flap increases the surface area of the flap and decreases donor site morbidity.

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